OPADE: Development of an European Computerized Drug Prescription System

Isabelle de Zegher[a], Claudine Milstein[b], Bertrand Séné[b], Bengt Dhalberg[c], Nigel Harding[d], Barbara Kostrewski[d] and Alain Venot[b]

[a]BIM, Belgium,
[b] Eclimed, Paris V University, Cochin Hospital, France,
[c]PharmaSoft Swedis, Sweden,
[d]Information Science, City University London, United Kingdom

Many computerized drug prescription systems have been developed but they are rarely used in clinical practice because of their lack of integration with the functioning of medical institutions and the difficulty of building and maintaining a complete knowledge base on drugs. We present in this paper a system, called OPADE, which answers these shortcomings and we argue that a system actually used by practitioners may introduce a positive feed back loop in the prescribing process.

1. INTRODUCTION

Computerized drug prescription system (CDPS) is an old - almost obsolete - dream, and numerous researchers have developed prototypes or even full fledged packages. However among the 37 systems we evaluated [1], the following shortcomings appeared repetitively:

- lack of integration with existing medical records;
- lack of integration/customization with local medical practice related to the prescribing process;
- lack of consideration of the prescribing cost;
- lack of complete, up to date knowledge base on drugs.

A direct consequence of this is the limited use of CDPSs by practitioners and their minimal impact on clinical practice. We argued in a previous paper [2] that all building blocks for implementing CDPS of clinical use are there, but they need to be integrated and adapted to the prescribing problem. Moreover, additional functions to compute the cost of a prescription and to provide tailored explanations to the patient increase the value of such a system. This paper describes the development of a prescribing optimization system to be piloted at hospital and GP sites in four European countries.

The paper is structured as follows. Section 2 provides a general description of the OPADE ("Optimization of drug prescribing using Advanced Informatics") project. Section 3 discusses briefly how the system will be integrated with existing medical record. Section 4 describes how we plan to build and maintain the system knowledge base within distributed sites and Section 5 presents our strategy to integrate OPADE with local medical practice. In Section 6 we discuss how a CDPS such as OPADE could influence prescribing practice.

2. DESCRIPTION OF THE OPADE PROJECT

OPADE aims at developing and evaluating an intelligent, multilingual CDPS adapted to different European countries. The system will allow for drug prescribing at the patient bedside in hospitals, or during consultations by general practitioners. The main objectives of the project are to

- increase the efficacy and safety of drug prescriptions by generating criticisms on physician choices; critiques will take into account both knowledge on drugs and relevant patient data;
- decrease the drug prescription costs by providing the physician with on-line information on prices;
- improve the follow-up of treatments by proposing schedules of biological tests;
- improve the patient compliance to the treatment by generating tailored explanations;
- facilitate the order entry at the computer board using knowledge based extended autocompletion techniques;

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- provide self audit tools which will allow auto evaluation of the prescriber practice using prescription data stored in the system.

An important differentiating factor between OPADE and other CDPSs is that it intends to provide support to the prescriber not only on the medical level but also on the economic and patient compliance aspects.

OPADE is being implemented following the client/server model where we distinguish three main blocks.

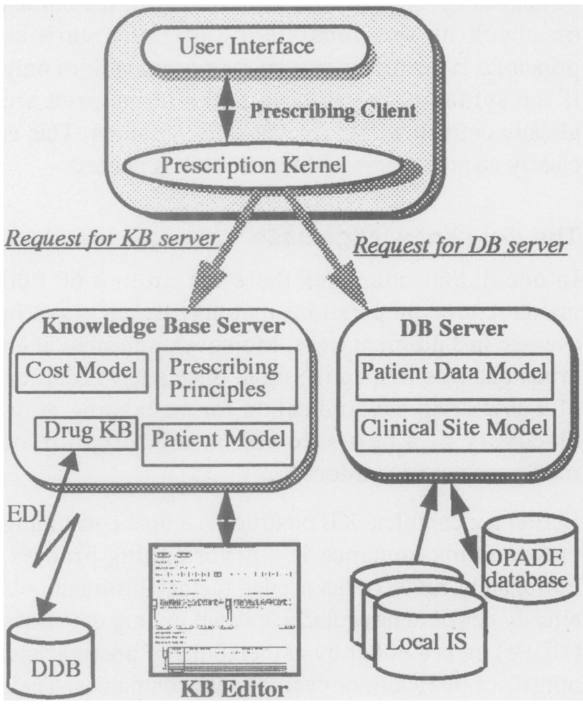

FIGURE 1. OPADE architecture

1. The Prescribing Client is composed by the Prescription Kernel and the User Interface; it is the core of the system which manages interaction with the user and requests the necessary information from the servers.
2. The Data Base (DB) Server which handles retrieval and storage of data needed by OPADE.
3. The Knowledge Base (KB) Server has four components:
   - Prescribing Principles that contain knowledge dealing with prescribing practice rules applied within a clinical site;
   - Cost Model KB that contains knowledge dealing with computation of cost and reimbursement. While modelling this component, we adopted a general approach allowing to manage the heterogeneity of the different reimbursement systems in place in European countries;
   - Drug KB that contains all information on drugs modelled following four levels: active components, generic, manufactured preparation and presentation;
   - State Model that contains knowledge used to derive information such as patho-physiological states from a patient's raw data.

   In these four components, we differentiate knowledge that is internationally accepted (e.g. pharmacokinetic effect), nationally validated (e.g. legal indication) or valid only at the local level (e.g. anti-hypertensive recommended by the local therapeutic committee).

The Prescription Client, the DB Server and the KB Server have been specified following the object-oriented analysis and design methodology of Coad and Yourdon [3]. In the resulting object models, each attribute of type string has been assigned a "systematic domain" [4]. Terms or codes corresponding to these "systematic domains" are defined in the OPADE Thesaurus. At installation time within a country, these values will be mapped with the terminology and coding systems in use in this country, allowing for transportability of the system.

3. INTEGRATION WITH MEDICAL RECORDS

A system such as OPADE has specific data needs to allow for optimization of prescription. For example, it is important to know the status of the patient renal function when prescribing drugs metabolized through the kidney. Similarly, it is important to know the socio-economical context of the patient to prescribe a drug scheduling intake in accordance with his/her lifestyle. OPADE will also output data related to drug therapy such as name of drug, regimen, adverse reaction on a drug, inclusion within a protocol...

Input data must ideally be retrieved from existing medical records to avoid retyping; output data must be stored preferably within existing software/hardware systems. In European hospitals, medical record is most often spread over several independent systems and OPADE will need to be integrated within this heterogeneous, distributed and autonomous DB context. Technical papers on this problem may be found in [5,6,7]. In OPADE we have chosen to follow the loosely coupled federated DB approach in the sense of [7]; our hypothesis is that a departmental system such as OPADE has a chance to be integrated only if it minimally disturbs local databases.

The Patient Data Model of the DB server (Figure 1) contains the specification of

- patient data, such as laboratory or physiologic measurements, needed for optimization of the prescription and that will have to be extracted from the existing medical records whenever possible;
- resulting prescription data related to the patient and that allow monitoring of the prescription.

This Patient Data Model is the data dictionary of a virtual DB that will fetch patient data from existing physical DBs through a Federated DB server. A crucial point to solve in the context of OPADE is the lifetime of the virtual objects. Indeed they will be composed from information of local DBs that may be updated after the OPADE virtual objects have been built. If the new information is life critical, it is fundamental that it is brought to OPADE before a final decision is taken.

4. BUILDING A KB FOR OPADE

We have identified four components in the OPADE KB server. Implementation of the Cost Model component is straightforward and consists in the entry of parameters specific for each country. For the purpose of this paper we will also consider that implementation of the State Model component is a relatively "easy" task because this knowledge is (1) limited to a set of states needed in the context of prescribing, (2) available from existing systems such as for example QMR and (3) not often modified so that maintenance is limited. On the contrary, implementation of the Prescribing Principles is harder because it needs classical knowledge engineering work in a domain less explored. Similarly, the size and variability of the drug knowledge component renders its building and maintenance difficult.

Prescribing Principles

Prescribing Principles encompass medical and common sense knowledge that link factual knowledge on drugs with structural knowledge on patient states. An example of a Prescribing Principle is: "avoid prescribing suppositories in patient with diarrhea". Four types of principles can be distinguished:

1. Logical, for which there is a rational explanation;
2. Rules of thumb, which are more empirical and deal mainly with common sense such as "no more than 5 drugs per patient";
3. Legal, which describe legal constraints on prescribing;
4. Policy constraints, which contain the principles set up by therapeutic committees to decrease wasteful prescribing.

To acquire and implement these Prescribing Principles we have a defined a fixed structure which reads as follow:

> *a "set of prescription feature":* Drug in drops
> *is "verb action":* to be avoided
> *in patient with "state value":* elderly
> *[for "prescriber characteristics"]*: null

A specialized editor respecting this structure is being implemented to facilitate entry of Prescribing Principles by experts. Currently almost all the burden on checking the consistency of these various principles is put on the expert; the system verifies only if the syntax is correct and if the terms used are already defined within the OPADE thesaurus. This is clearly an area where additional work is needed.

The drug knowledge base

In occidental countries there are around 60.000 manufactured preparations that may be packaged in average in 3 different ways. Moreover, information on drugs changes frequently, up to once a day: addition of a new drug, new indication for an existing drug, discovery of a new side effect, modification of reimbursement conditions,.....

Building a complete KB on drugs is a time consuming task, and maintenance is a never ending process. Fortunately, much of the needed factual information is already stored and regularly updated in drug databases (DDBs) owned either by associations of pharmacists, ministries of Health or even private companies. Their goal is to provide rapid access to accurate information on drug for the prescriber. There are two types of DDBs:

- those that contain free text and that are in fact an electronic version of a pharmacopeia such as Martindale in the UK;
- those that store the information in a structured way such as First Data Bank in the US, Thériaque in France, Swedis in Sweden, ABDA in Germany.

An electronic transfer of information from the structured DDBs to OPADE will partially solve the problem of building and maintaining the drug KB. This transfer must rely on the elaboration of structured messages having a precise syntax. In OPADE, we have defined this syntax following the methodology recommended by the CEN/CENELEC TC 251, WG3, PT004 [8]. The main advantage of this method is to allow to isolate the problem domain, i.e. the definition of message structure, from the implementation of these messages within a specific syntax such as ASN.1, EDIFACT, Euclides, HL7 or ASTM.

Building and maintaining the drug KB of OPADE requires the following steps:

- elaboration of an OPADE message from the DDB either when a new OPADE KB must be built or when new information is entered within the DDB. If there is a semantic mismatch between OPADE and the DDB, the information contained in the DDB must be mapped down to the format expected by the OPADE system and defined in its thesaurus. The syntax of the message must correspond to the syntax defined for the OPADE messages;
- sending the message by X-400;
- insertion of the information contained in the message in the right place within the drug KB;
- manual completion of the drug KB through a specialized editor; from the surveys we have performed of European DDBs it appears clearly that not all the information we need for optimizing prescription can be found in these DDBs.

5. INTEGRATION WITH LOCAL PRACTICE

"Those systems that have been most widely accepted tend to rely on the use of a combination of monitoring, critiquing and assisting techniques that run unobstructively in the background, providing guidance and reminders only when and where they are needed" [9]. From this, we can infer the golden rules any departmental system should follow

"Thou shall not disturb"
"Thou shall be useful"
"Thou shall be safe"

Thou shall not disturb

This commandment comes down to the following requirements.

- Prescriptions through OPADE should not take more time than what is required with the existing method. We will use autocompletion technique to ease entry of a prescription order. Moreover, retrieval time of patient data stored in local records will be optimized by copying already available information into a DB dedicated to OPADE; update of this information will happen on request.
- Interaction with OPADE should be easy. In the User Interface, we have adopted a set of metaphors exploiting prior knowledge that the user has about prescribing context. To insure homogeneity of interactions, we have defined graphical conventions for icons and interactive buttons.
- There should be no modification of existing prescribing practice rules. Institution have their prescribing habits and the local therapeutic committee defines rules that have to be respected by the prescriber of the institution. OPADE should take these rules into account when evaluating a prescription; they will be embedded within the Prescribing Principles component of the KB server.

Thou shall be useful

The critiquing capacity of OPADE has been developed in a multi-goal perspective.

- Errors or inadequacies in drug prescribing will be detected by checking each prescription separately, and with respect to the others. For instance, dose errors, contra-indications, interactions, treatment duration errors, non availability of the drug will be checked at prescription entry.
- Whenever possible these criticisms will be followed by suggestions such as usual dose, drugs of the same therapeutic group with no interactions, other pharmaceutical forms of the same commercial product, cheaper drug with similar therapeutic effect.
- Fitness of treatment to patient features such as their age, sex, job and life-style will be analyzed. Recommendations, such as cautions to be taken because of the sedative effect of a drug, will then be generated.
- Finally the system will produce reminders aimed at facilitating the treatment follow-up, such as elements to tell orally to the patient, biological tests not to forget, clinical examinations to be planned.

Thou shall be safe

OPADE critiques must be safe with respect to existing data about the patient, information about drugs and established prescribing practice rules. Mechanisms to insure integration with medical record and reliability of the knowledge have been foreseen in the design of OPADE. A formal evaluation based on pre-defined criteria organized in a protocol will be conducted to verify system efficacy and safety. But it must be clear that reliability of incoming information in a system with evolving knowledge such as OPADE remains the responsibility of the information provider. Moreover OPADE is a decision *support* system and does not aim at replacing the human prescriber who remains the final responsible.

6. DISCUSSION

In the design of OPADE, particular attention was payed to the integration of the system in clinical practice in an undisturbing way, while providing complete knowledge on drugs and additional support in terms of reminders, cost information and explanation to patient. Our aim is to have the system really used in everyday practice. The system evaluation that will take place in four different European countries mid '94 will tell us if we succeeded.

If this is the case, the system should be further used to introduce a positive feed back loop in the prescribing process. It is well known that adverse reactions happen in 10 to 20% of the prescriptions [10]; moreover cost expenditure in the health care sector, and particularly in the drug delivery area, are increasing each year. If OPADE is actually used by all prescribers within a clinical institution, the output of the system can be studied to identify prescription patterns at the individual or institutional level.

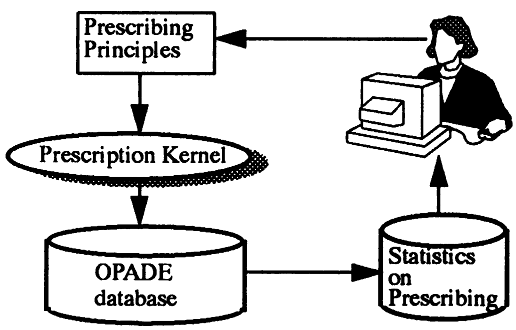

FIGURE 2. OPADE loop

These patterns can be further analyzed by the local therapeutic committee and Prescribing Principles can be derived to correct bad prescribing practice and/or to enforce adequate practice. Once introduced in the system knowledge base, these new principles will be the source of new types of suggestions or reminders. Several studies have showed that attitudes of clinician is influenced by a critiquing system [9,10,11]; it is hoped that the evolving critiques generated by OPADE will influence directly the prescribing attitude of clinicians.

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